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EFFECT OF TWIST ON THE PHYSICAL PROPERTIES OF A NUMBER 7S YARN

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ABSTRACT

This investigation was made to determine the most suitable twist for manufacturing the yarn to be used in the Pima post office bag investigation. Data were obtained on the relation of the twist to the breaking strength, diameter of the yarn, yarn count, contraction, and angle of twist. While these data were not sufficiently extensive to attempt to fix definite formula for these relations, it is thought that the tabular and graphical relation studied in this investigation will be useful for the cotton manufacturer. The most suitable twist for the yarn to be used in the Pima mail bags was found to be about 12 turns per inch.

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I. INTRODUCTION

There are many different ideas regarding the amount of twist[1] which should be given to a cotton yarn to serve any specific purpose. These opinions have been founded more or less on observation and fact, but sometimes they have no sound reasonable basis. For instance, the terms "hosiery twist," "warp twist," "filling twist," etc., are used with numerous ideas as to just what they comprise, for they vary considerably from mill to mill, and even within the organization of a single mill marked variations in practice occur. This condition results primarily on account of lack of fundamental data. If it were known, for example, just what is the effect of a change in the twist on the breaking strength, diameter, etc., of the yarn, a more comprehensive basis for fixing the organization requirements in the manufacture of the yarn might be obtained.

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[1] The twist of the yarn may be defined as the number of turns in a definite length of yarn, as turns per inch.

Data available on the effect of a change in twist on the other physical properties of the yarn should be very useful to the cotton manufacturer. The data on the effect on the diameter alone will solve many difficulties, for a change in diameter may necessitate a change in threads per inch. In that case unless the threads per inch were changed there would result a definite change in the appearance and probably the usefulness of the fabric. The effect of a change of twist on the breaking strength is of vital interest to manufacturers of those mechanical fabrics, the strength of which is an influencing factor. While the effect of a change in the angle of twist is not so directly evident, various uses may be found for these data.

It is with this idea that the results of this investigation are offered with the hope that it will be useful as a basis for further work along this line. The immediate need for these data at this bureau was to find the most suitable twist for the manufacture of yarns to make duck for the use of post-office mail bags.[2]

II. PURPOSE

The purpose of this investigation was to determine the effects on the physical properties of the yarn, resulting from changing the twist in the spinning process on number 7s cotton yarn. The physical properties studied were yarn count, diameter, contraction, angle of twist, and breaking strength.

III. METHOD OF MANUFACTURE

The cotton used in this investigation was classed as No. 2 Pima, or Arizona-Egyptian cotton, fully equal to middling Upland in grade. The average staple length was 1⅝ inches.

The number of mill processes were kept as few as possible and still produce a good quality of yarn.

The following organization was used:[3]

Automatic feeder	14.4-ounce lap.
Vertical opener	
Breaker picker	
Finisher picker	11.6-ounce lap.
Card	45-grain sliver.
Drawing frame	46-grain sliver.
Drawing frame	
Drawing frame	
Slubber	1.04-hank roving.
Spinning frame	7s yarn.

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[2] Comparative Wearing Qualities of Pima and Ordinary Cotton Used in Mail Bags, B. S. Tech. Paper No. 277.

[3] Complete organization is given in B. S. Tech. Paper No. 277.

When the fibers are delivered from the front roll of the spinning frame they are practically parallel, but they are twisted immediately to an extent which will give them sufficient strength so that the yarn can be wound on the bobbin in a continuous strand and can proceed through the further processes of manufacture without breaking. While the lowest limit of twist is generally determined by the workability of the yarn, the number of turns additional in the later processes depended upon the use for which the yarn is intended.

In this investigation the twist was varied at the spinning frame to produce from about 7 to 19 turns per inch. The same draft (ratio of input to output) was used for all twists.

IV. METHODS OF TEST

1. CONTRACTION

Contraction in the yarns is the decrease in their length produced by some physical or chemical force. This can be caused, as was the case in this study, by an increase in the twist. A measure of the contraction can be obtained in two ways:

(*a*) Weight Determination.—The difference in weight for a given number of yards before and after the twisting process; that is, weight difference divided by length.

(*b*) Draft Measurements.—As the yarn contracts with increase in twists, it is necessary to regulate the draft in order to keep the weight of the yarn constant. The feed is, therefore, diminished in proportion to the increase in weight. This amount can be calculated and the contraction ascertained.

In this investigation, since the same draft was used for all twists, the contraction was measured from the increase in weight only. The method used was as follows: After conditioning for at least four hours in an atmosphere of 65 per cent relative humidity and 70° F. temperature, from each of three bobbins of each different twist a hank of 120 yards was reeled and weighed.

2. YARN COUNT

The yarn size is figured on the basis of the number of yards for a definite weight. In the case of cotton it is the number of 840-yard hanks which will weigh 1 pound. The results in this investigation were obtained from the weights of 120-yard lengths above mentioned.

3. DIAMETER OF YARN

The diameter of the yarn of a definite weight varies as the twist is increased or decreased. The low-twisted yarn is larger in diameter and softer than the hard-twisted yarn. The procedure used to measure the diameter of the yarn was as follows: A photograph of several lengths of yarn which had been magnified 40 times was taken. On these prints, several of which are shown in Figure 1, at intervals of 1 inch a measurement of the diameter was made in one-sixteenth inch.

4. ANGLE OF TWIST

Attention has already been called to the reasons for twisting the yarn. The angle of the twist resulting from the twisting operation is the angle which the twisted fibers make with the longitudinal axis of the yarn.

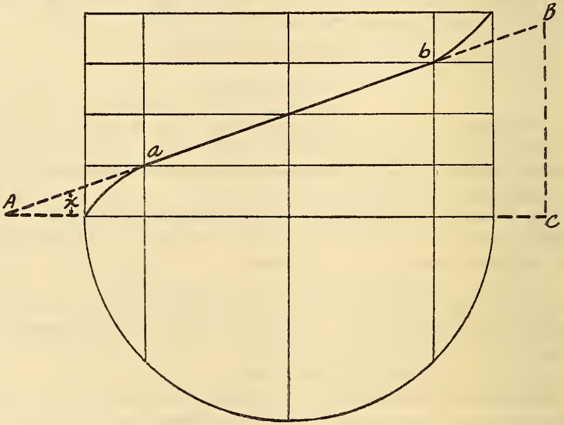

Fig. 2.—*The projection of a helix on a plane. The reading obtained for angle of twist was the angle x*

The reading obtained was in fact a measure of the helix angle, for as shown in Figure 2 the projection of the helix angle on a plane produces a straight-line portion ab, which when taken in its relation to the horizontal is a measure of the helix angle. If the cylinder is rolled out on a plane the development of the helix will be a straight line AB with slope equal to tan x. Measurements were made by arranging a protractor on a large sheet and using a pivoted pointer. Care was taken to fix the limits of the measurements on the straight-line portion. (Readings made on photographs similar to fig. 1.)

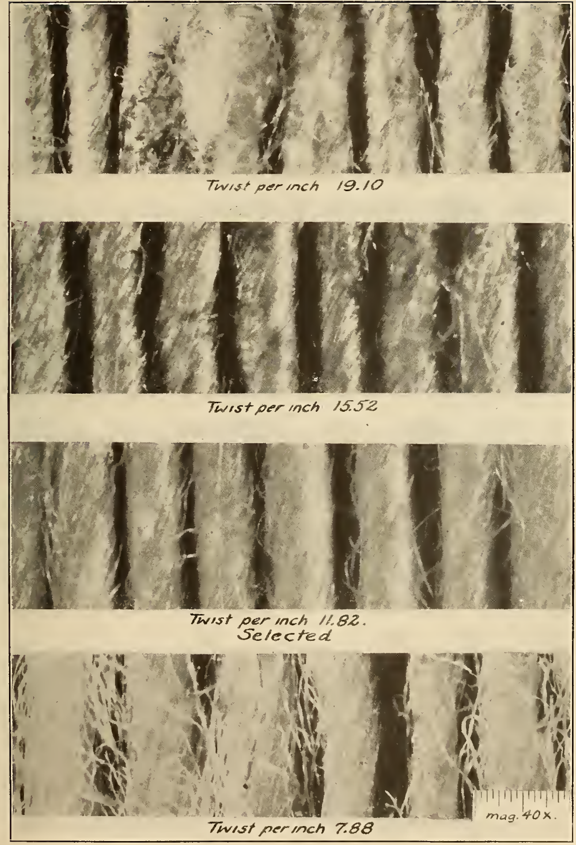

FIG. 1.—*Pima cotton yarn (magnified) with twist as indicated. Soft yarn resulting from too low a twist and bursts resulting from excessive twist are evident*

5. BREAKING STRENGTH

The twist is an important factor in obtaining the strength of a yarn. In the twisting process the fibers are entwined around and cling to each other, so that they resist efforts to slip by each other. Theoretically the maximum strength is obtained when sufficient twist is given which will, with minimum strain to the individual fibers, prevent any slipping when force is applied in a longitudinal direction. Beyond this point the strength decreases and this decrease can be continued until the yarn breaks under no longitudinal strain, but merely from the shearing action of the twisting. Bursts occurring from excessive twist are evident in Figure 1. Excessive twisting, in addition to lowering the breaking strength, causes kinking in the yarn, which renders it difficult to handle.

The strength of the yarn is not always the governing factor in preparing a textile material for use. It has been pointed out that the greater the twist the harder the yarn. This hardness may be an undesirable quality, and it may be necessary to sacrifice the strength feature to obtain a characteristic which is more desirable for the use for which the product is intended. Knitting yarns, for instance, are generally soft, low-twisted yarns, because the yarns are easier to handle on the knitting process, and the resulting product is desired to be of soft quality.

The breaking-strength method used was the single-end method. For each strength determination three bobbins of yarn were taken at random, from each of the various lots of different twists. All tests were made after conditioning for at least four hours in an atmosphere of 65 per cent relative humidity and 70° F. temperature. The testing was done on an inclination balance type of machine. Ten to twenty breaks were made from each bobbin, and these breaks were averaged for the bobbin, and then these averages were averaged to obtain the result for that particular twist.

V. DISCUSSION OF RESULTS

A summary of the tests are given in Table 1.

TABLE 1.—*Summary of results on Pima yarn (7s) of varying twists*

Number	Diameter $\frac{1}{16}$ inch, magnification 40×	Breaking strength	Count of yarn	Turns	Twist multiplier	Weight of 120 yards	Twist gear	R. p. m. front roll	Angle of twist
		Pounds				*Grains*			*Degrees*
1	10.9	2.85	7.22	7.88	2.98	141.7	63	340	19.0
2	10.1	2.71	7.04	8.56	3.23	141.9	58	310	19.7
3	9.5	3.05	6.93	9.20	3.47	144.3	54	290	21.0
4	10.1	3.22	6.93	9.93	3.75	144.7	50	270	21.7
5	8.0	3.23	6.93	10.57	4.00	144.8	47	250	24.0

Table 1.—*Summary of results on Pima yarn (7s) of varying twists*—Contd.

Number	Diameter 1/16 inch, magnification 40×	Breaking strength	Count of yarn	Turns	Twist multiplier	Weight of 120 yards	Twist gear	R. p. m. front roll	Angle of twist
		Pounds				*Grains*			*Degrees*
6	9.8	3.36	6.73	11.28	4.26	148.6	44	230	24.0
7	8.9	3.47	6.72	11.82	4.47	148.8	42	220	24.0
8	8.8	3.39	6.70	12.41	4.69	148.6	40	210	26.0
9	8.8	3.41	6.72	13.07	4.96	148.8	38	200	26.0
10	8.8	3.37	6.62	13.79	5.21	151.0	36	190	28.3
11	8.1	3.25	6.50	14.60	5.52	153.9	34	180	29.0
12	7.7	3.31	6.53	15.05	5.68	153.1	33	175	31.3
13	8.8	3.68	6.44	15.52	5.86	155.2	32	170	30.7
14	7.0	3.57	6.31	16.02	6.06	158.4	31	164	32.3
15	7.7	3.40	6.38	16.55	6.26	156.7	30	160	31.3
16	7.6	3.32	6.20	17.12	6.47	161.2	29	154	32.7
17	7.2	3.33	6.21	17.73	6.70	161.0	28	150	34.3
18	8.1	3.27	6.19	18.39	6.95	161.4	27	145	36.3
19	7.6	3.17	6.07	19.10	7.22	164.7	26	138	38.0

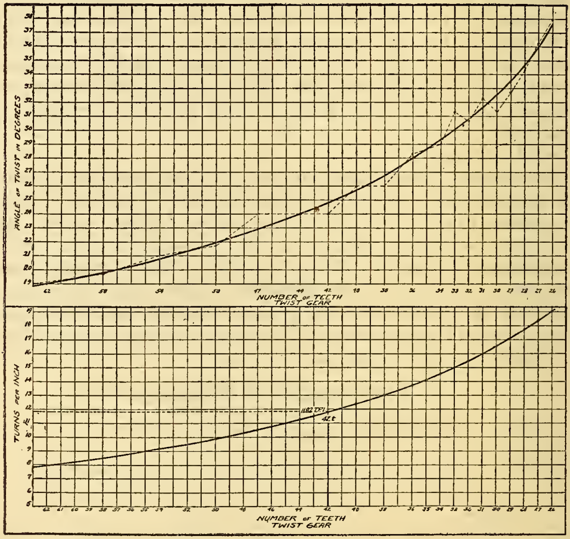

Fig. 3.—*Relation of the number of teeth in the twist gear to the twist per inch (finished yarn) and to the angle of twist (finished yarn)*

A comparison of the relations of the number of teeth on the twist gear to the turns per inch and to the angle of twist of the yarn is shown in Figure 3. The relation of the angle of twist to the number of turns per inch is shown in Figure 4. The broken line connects the actual averages obtained. These angle measurements vary to some extent, due to the unevenness of the yarn; for when thick and thin places occur in the yarn the twist tends to run to the thin places during the spinning operation. This was clearly marked in some of the photographs.

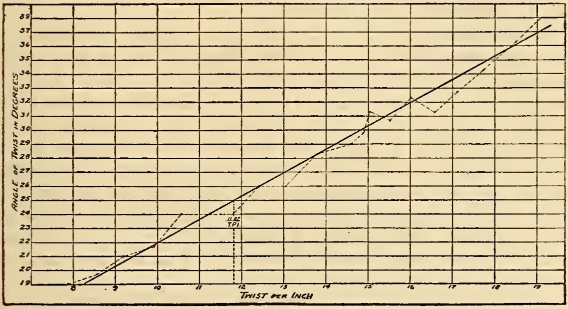

FIG. 4.—*The relation of the twist per inch to the angle of twist*

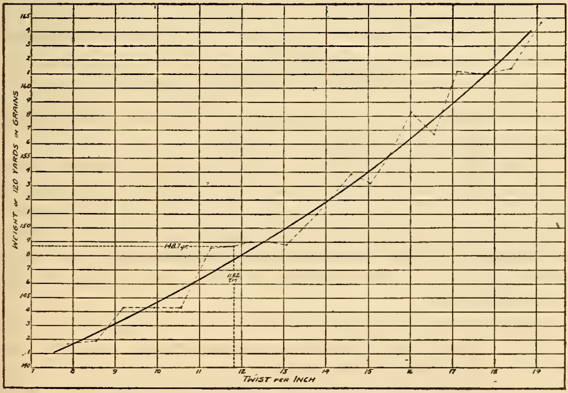

FIG. 5.—*The relation of the twist to the weight of 120 yards*

The contraction of the yarn is shown in Figure 5 by plotting the increase in weight of 120 yards of yarn as the number of turns per inch increases. The irregularity of the yarn is indicated by the variations of the points, which are connected for convenience by a broken line. Figure 6 shows what effect the change in twist has on the yarn size. In Table 1 it is shown that the yarn count changes from 7.22 using 7.88 turns per inch to 6.07 using 19.10 turns per inch, a difference of over one count.

The diameter of the yarn for any twist varied considerably; in fact, cases occur where the variation of one lot was as great as the variation of the whole group. The averages were taken from the average results of measurements of seven yarns for each lot which had been magnified forty times. Figure 7 shows a frequency graph of these readings. It shows the range of the individual lots of yarns and the mode. Figure 8 shows a curve obtained by plotting the averages of the diameters for each twist against the twist per inch. That the diameter decreases with the increase in twist per inch is evident. This decrease is more marked in the smaller number of turns per inch, which is expected, for as the yarn twist increases it becomes more compact and further increases will not decrease the diameter to as great an extent.

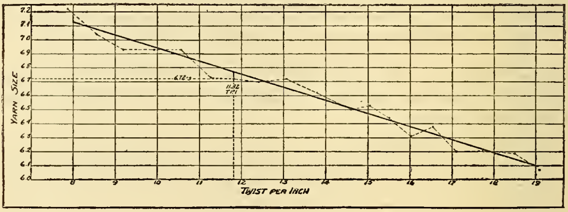

FIG. 6.—*The relation of the twist to the yarn size*

In this experiment the relation of the breaking strength to the twist per inch was most important. The results of 10 breaks on three different bobbins from each lot representing a different number of turns per inch were averaged, and the average of these three was obtained. Figure 9 shows the frequency of occurrence of the readings included in these averages. The arrows indicate the final average obtained.

Figure 10 shows the relation of the breaking strength to the turns per inch. The irregularity of the points (which have been connected for convenience) indicates that a larger number of tests would have to be run to establish definitely a smooth curve which logical considerations seem to indicate. This smooth curve is placed on this graph for convenience. However, these results permitted a satisfactory conclusion of the problem, for they showed that the region of greatest strength was between 11.5 and 16 twists per inch. The increase in strength obtained by the higher twist would not be

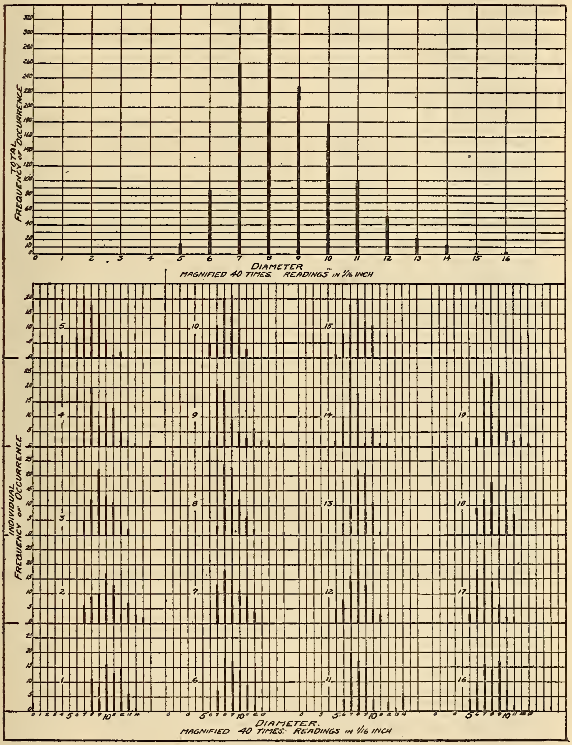

FIG. 7.—*The frequency of occurrence of the diameter of the yarn for the individual lots of yarns and the total frequency*

Shows the range and mode .

sufficient to warrant its use on account of the additional cost of spinning this higher number. It was accordingly decided to use 11.8 turns per inch. (This is shown in fig. 11.)

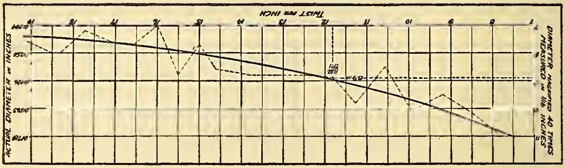

FIG. 8.—*The relation of the twist per inch to the diameter of the yarn*

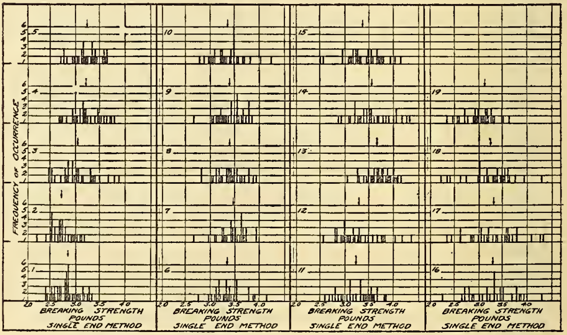

FIG. 9.—*The frequency of occurrence of results of breaking strength (single-end method)*

Arrows indicate the average of each type

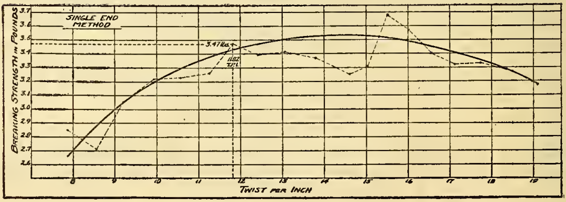

FIG. 10.—*The relation of the twist to the average breaking strength*

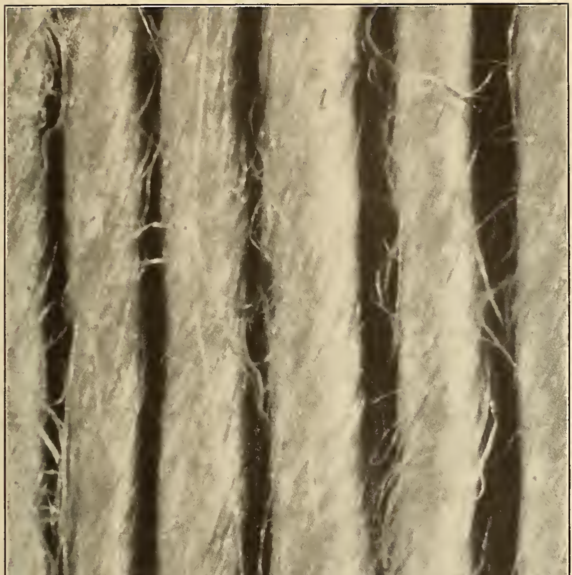

FIG. 11.—*Pima yarn (magnified) showing the twist which was selected for manufacturing yarn for the experimental post-office bags. Twist per inch 11.82, count 6.7s*

VI. SUMMARY

The results of this study may be summarized as follows:

1. It was found that the limits of the twist with the organization used for spinning a 7s yarn of Pima cotton were from 7 to 19 turns per inch. Accordingly, the twist was varied at the spinning frame to produce twists between these limits. The same draft was used for all twists.

2. The angle of twist ranged from 19 to 38° for this range of twists.

3. The contraction, as indicated by the change in weight of 120 yards, ranged from 140 to 165 grains. This is equivalent to a contraction range of 17 per cent, based on the weight of the lowest twist.

4. The yarn size was changed from 7.2s for 7 turns per inch to 6.1s for 19 turns per inch, a change to a full count.

5. The diameter of the yarn varied considerably, but a decrease was shown as the twist was increased. This was not so marked as the higher twists were reached. The fuzziness of the yarn, which was marked on the lower twists, decreased as the twist increased. Reference to the twist 19.10 per inch shown in Figure 1 shows the fibers bursting on account of excessive twist, which indicates that the limit of compression has been reached.

6. The breaking strength results, which were of primary importance in this study, showed that the region of greatest strength was between 11.5 and 16 twists per inch. The increase in strength obtained by the higher twists in this region would not be sufficient to warrant their use on account of the additional cost of spinning this higher number.

7. The twist per inch selected as most suitable was 11.8 turns per inch.

WASHINGTON, June 27, 1924.